Advanced Power Electronics

Wide Bandgap Materials

Background

Power devices used in traction applications must be able to handle extreme environments which include a wide range of operating temperatures. Because of their physical properties, silicon (Si) devices have generally reached their operating temperature limits in such conditions.

Silicon carbide (SiC) has been identified as a material with the potential to replace Si in power devices. SiC-based devices are capable of operating at high voltages, high frequencies, and at higher junction temperatures. It is projected that significant reductions in the weight and size of SiC power electronics as well as an increase in operational efficiency can be achieved through utilization of this semiconductor technology.

Technology

The Oak Ridge National Laboratory (ORNL) has been assessing the impact of replacing Si power devices in transportation applications with SiC-based power devices.

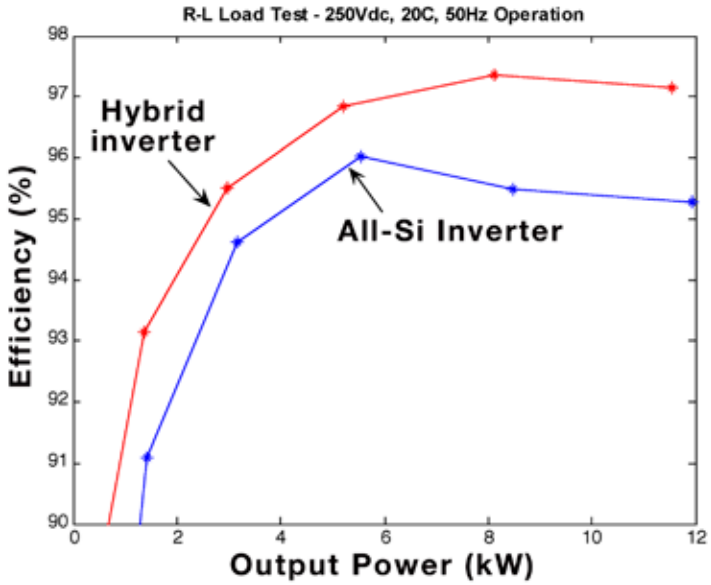

***Figure 1**. Efficiency comparison of a 55-kW Si IGBT-SiC Schottky diode and a similarly rated all-Si inverter.*

The use of SiC is projected to significantly reduce the weight and size of current power electronics, as well as increase operational efficiency.

Extensive dynamometer and inductive load testing of this hybrid inverter showed a reduction of up to 33.6 percent in inverter losses. When SiC main switches also replace their Si counterparts, inverter losses are expected to be reduced by up to 65 percent.

Benefits

- Enables higher power density.
- Improves reliability and lifetime by lowering operating temperatures for the electronics.
- Allows increased silicon chip power throughput.
- Shares existing components under the hood of the vehicle.

Status

Recently, ORNL collaborated with Cree and Semikron to build a 55 kW Si IGBT and SiC Schottky diode inverter. Schottky diodes are the only SiC devices that are presently commercially available and are provided by only a handful of manufacturers. Several companies and universities are developing other SiC and gallium nitride power electronics devices, but have not yet introduced commercial products for JFETs, IGBTs, or MOSFETs. SiC device manufacturers are expected to commercialize SiC JFETs and MOSFETs.

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